Lesson 1-2: Connectivity and Internetworking Devices

At a Glance

Connectivity devices are devices used to make physical network connections. They do not make changes to the data or transmission route. Connectivity devices operate at the physical layer of the Open Systems Interconnection (OSI) model.

Internetworking devices move data across a network. They may direct data to specific locations within the network and/or convert data into alternative formats. Internetworking devices operate at OSI layers above the physical layer.

Understanding the functions of these devices and how they fit within the OSI model will help you learn how networks function.

What You Will Learn

After completing this lesson, you will be able to:

- Identify network connectivity and internetworking devices.
- Match the appropriate level within the OSI model to which each device is assigned.
- Compare the functionality of connectivity and internetworking devices.

Tech Talk

- **Bridge**—Network segments that typically use the same communication protocol use bridges to pass information from one network segment to the other.
- **Gateway**—When different communications protocols are used by networks, gateways are used to convert the data from the sender's
- **Hub**—Another name for a hub is a concentrator. Hubs reside in the core of the LAN cabling system. The hub connects workstations and sends every transmission to all the connected workstations.
- **Media Dependent Adapter**—A MDA is a plug-in module allowing selection among fiber-optic, twisted pair, and coaxial cable.
- **Media Filter**—When the electrical characteristics of various networks are different, media filter adapter connectors make the connections possible.
- **Multistation Access Unit**—MAUs are special concentrators or hubs for use in Token Ring networks instead of Ethernet networks.
- **Network Interface Card**—NICs are printed circuit boards that are installed in computer workstations. They provide the physical connection and circuitry required to access the network.
- **Repeater**—Connectivity device used to regenerate and amplify weak signals, thus extending the length of the network. Repeaters perform no other action on the data.
- **Router**—Links two or more networks together, such as an Internet Protocol network. A router receives packets and selects the optimum path to forward the packets to other networks.
- **Switch**—A connection device in a network that functions much like a bridge, but directs transmissions to specific workstations rather than forwarding data to all workstations on the network.
- **Transceiver**—The name transceiver is derived from the combination of the words *trans*mitter and re*ceiver*. It is a device that both transmits and receives signals and connects a computer to the network. A transceiver may be external or located internally on the NIC.

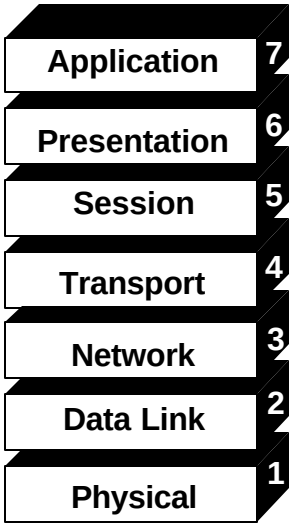
Connectivity Devices

Connectivity devices are those devices used to make physical network connections. Connectivity devices operate at the physical layer of the Open Systems Interconnection Reference Model (OSI) model. The OSI model describes how computer services and procedures are standardized. This standardization allows computers to share information and enables the interconnection of various networking connectivity devices regardless of vendor.

The OSI model uses the concept of seven stacked layers to define a network communications system.

The lower three layers: Physical, Data Link, and Network, deal mostly with network-dependent (hardware) functions.

The OSI Model



The upper four layers: Transport, Session, Presentation, and Application, deal more with application-oriented (user or software) functions.

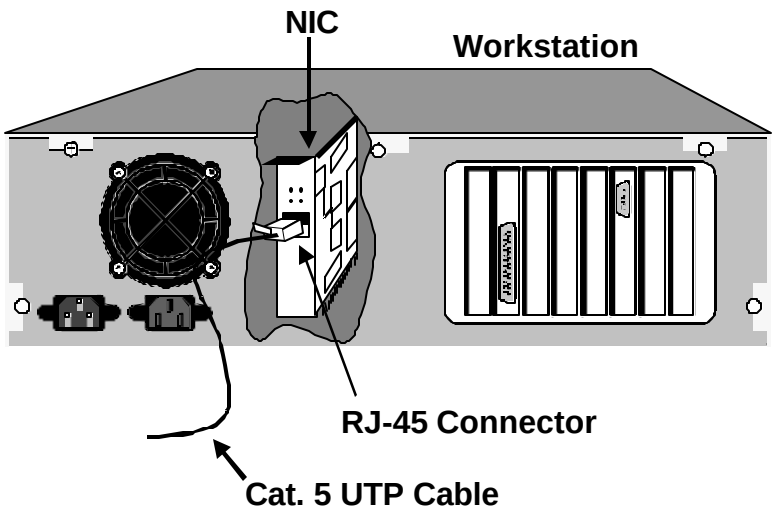
Generally speaking, these connectivity devices are passive in their actions, meaning that they do not make changes to either the data or the transmission route of that data. These devices simply provide the physical link between workstations and other network devices.

Network Interface Card

Network interface cards (NICs) are printed circuit boards that are installed in workstations. They provide the physical connection between the network cable and the workstation. In addition, they possess the circuitry necessary to gain access to the network.

In the past, computers did not come with a pre-installed NIC. However, most modern computers are shipped with NIC already installed and ready to be connected to a network.

Network Interface Cards are Installed Inside Workstations



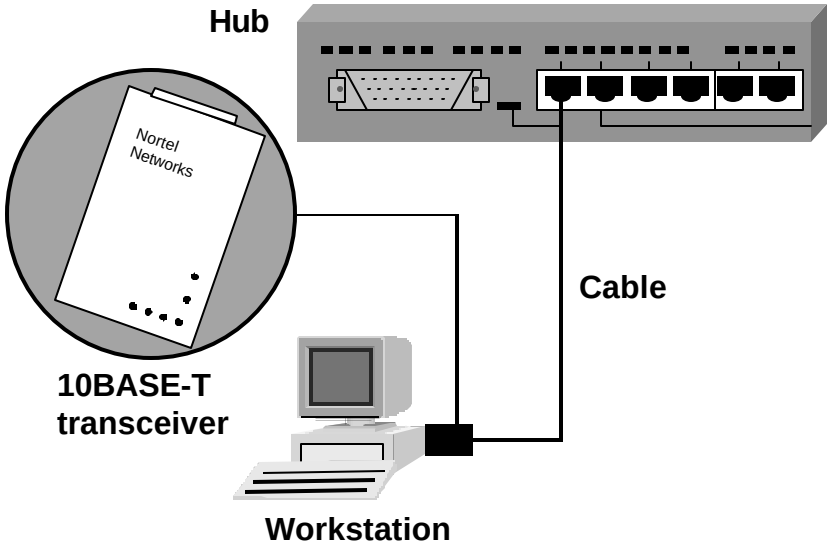
- Each NIC has a distinctive 6-byte hardware address that identifies the workstation within a segment, such as Ethernet 00-00-A2-9A-4E-10.
- Each NIC has at least one connection port where the network cable is attached. Only one port may be used at any one time.

- The NIC formats information from the workstation so that it can be transmitted across the network.
- Although the NIC operates at the physical layer of the OSI model, it is also considered a data link layer device. Part of the NIC's function is to format information between the workstation and the network, and also, to control the transmission of data onto the wire.

Transceivers

The name transceiver is derived from the combination of the words *trans*mitter and re*ceiver*. It is a device that both transmits and receives signals along the network cable and connects a computer to the network.

Transceivers May Be External or Located on the NIC

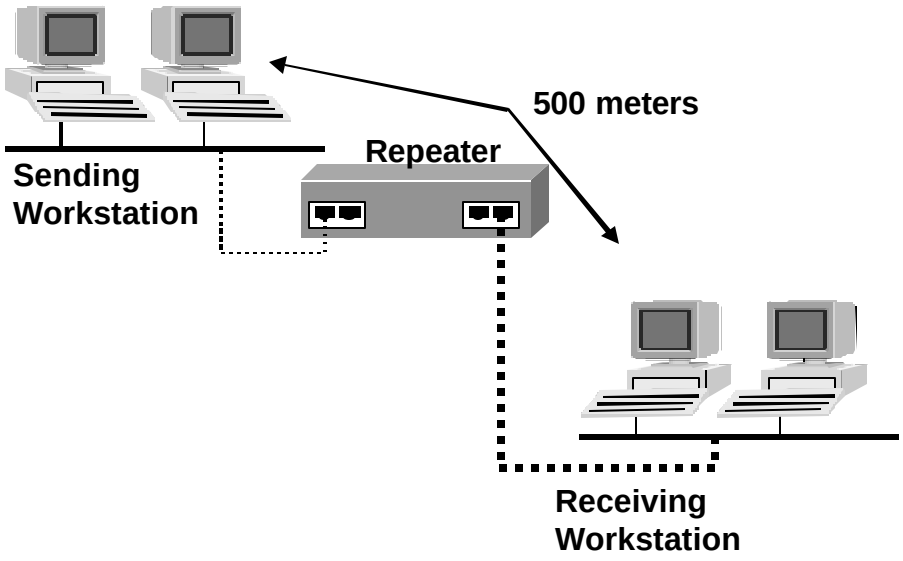


- Today, most transceivers are built into the network interface cards. Older transceivers were clamped onto the network cable and then connected to the NIC.
- The transceiver does not make changes to information transmitted across the network, it adapts the signals so devices connected by varying media can interpret them.
- A transceiver operates at the physical layer of the OSI model.

Repeaters

As data travels through cabling systems, a certain amount of electrical interference and signal loss is inevitable. As the need for larger networks that span greater distances developed, a solution was needed to resolve signal loss over the network. Repeaters were created to regenerate and amplify weak signals, thus extending the length of the network. The basic function of a repeater is to retime, reshape, and reamplify the data signal to its original level.

Repeaters Amplify Weak Signals

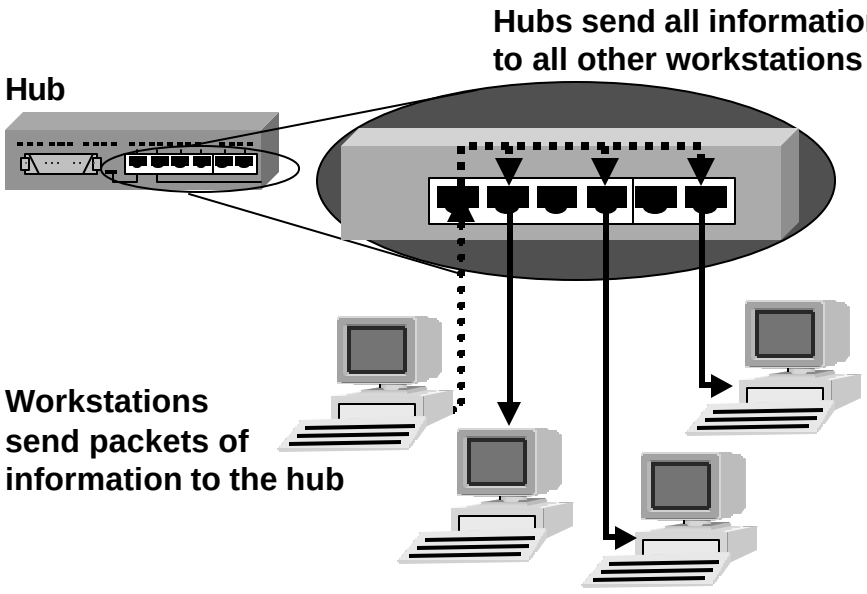


- Repeaters perform no other action on the data.
- Repeaters were originally separate devices. Today, a repeater may be a separate device or it may be incorporated into a hub.
- Repeaters operate at the physical layer of the OSI model.

Hubs

Hubs, sometimes called concentrators, reside in the core of the LAN cabling system. They are basically multiport repeaters. The hub connects workstations and sends every transmission to all the connected workstations. They work much like the old telephone party lines, where only one computer can "talk" at a time.

Hubs Connect Workstations Together



- The receptacles on the front of the hub are called *ports*. There are usually from 4 to 32 ports on a hub, depending on the size of the network.
- Some hubs have an additional interface port that connects to another hub, thus increasing the size of the network.
- Hubs operate at the physical layer of the OSI model.

Media Dependent Adapter

A media dependent adapter (MDA), sometimes referred to as transceivers, is a module added to a hub to provide flexible cable connectivity. These optional devices provide a connection port for a cable connector that is different than the hub's ports. For example, a MDA can be used to connect a fiber-optic cable to a hub with RJ-45 connectors otherwise not compatible with fiber-optic connectors.

- Media dependent adapters are also used on servers, switches, routers, transceivers, and to make direct connections to end stations.
- MDAs function at the physical layer of the OSI model.

Media Filters

A media filter is a very specialized kind of adapter used on token ring networks. When token ring networks were first implemented, they used shielded-twisted pair (STP) cabling. Token ring networks now use unshielded-twisted pair (UTP) cables.

There is a difference in the electrical characteristics between these cabling systems. If a STP-specific network interface card in a token ring network is connected to a UTP cable, the network data signal will be damaged. Attaching media filters between the NIC and the UTP cable reduces the interference and prevents damage to the data. Media filters function at the physical layer of the OSI model.

Check Your Understanding

- ♦ Explain why a network interface card may be considered part of both the physical layer and the data link layer of the OSI model.
- ♦ Diagram a functioning hub and explain how a hub functions.

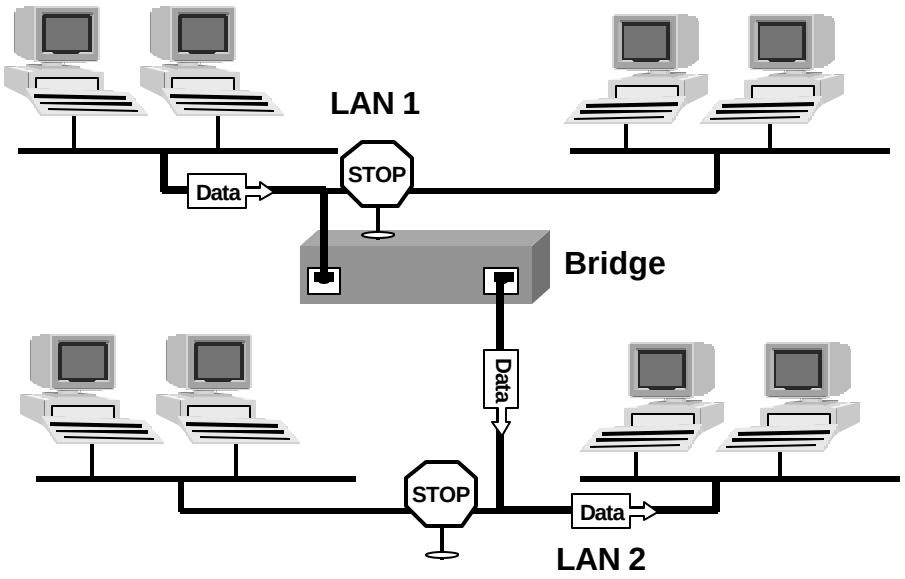
Internetworking Devices

As networks became increasingly complex, the need for internetworking devices also increased. Internetworking devices are active components rather than passive. They are considered active because they do more than simply pass data across a network. They make "intelligent" decisions and may interpret, reformat, and/or direct data as it passes through a network. Internetworking devices typically operate at OSI model layers other than the physical layer.

Bridges

Bridges connect network segments typically using the same communication protocol, passing information from one network to the other. A bridge may divide an overloaded network into smaller, more efficient networks. Bridges break networks into separate segments and direct transmission to the appropriate segment much like a police officer directs automobile traffic.

Bridges Segment Networks and Direct Traffic



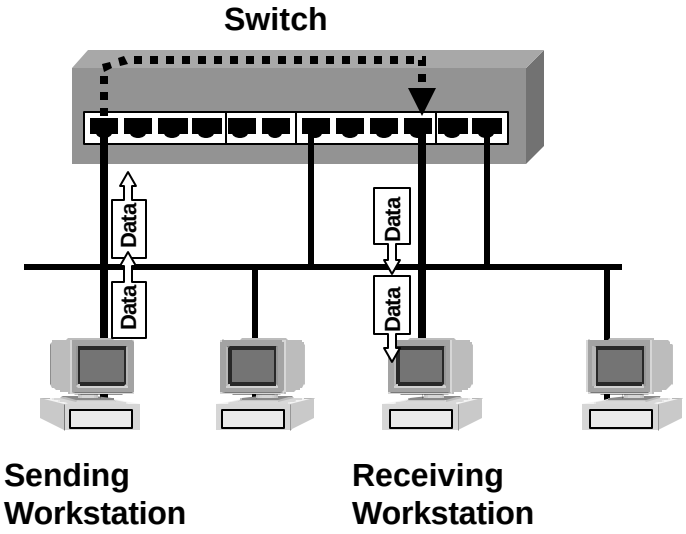
- Bridges learn which workstations are on what network segment by looking at the hardware address in the frames it receives and entering this information into a table.
- Bridges function at the data link layer of the OSI model.

- A bridge monitors information passing over a network segment and restricts the flow of unnecessary information. It also listens to all traffic on the segment, determines the destination address, looks up the destination address in the table, and then passes the frame to the correct segment.
- Bridges can be used to connect different types of cabling from one LAN to another.

Switches

One way of relieving network congestion is to use a switch, either in place of a hub or bridge, or in addition to a hub.

Switches Direct Information to Specific Workstations



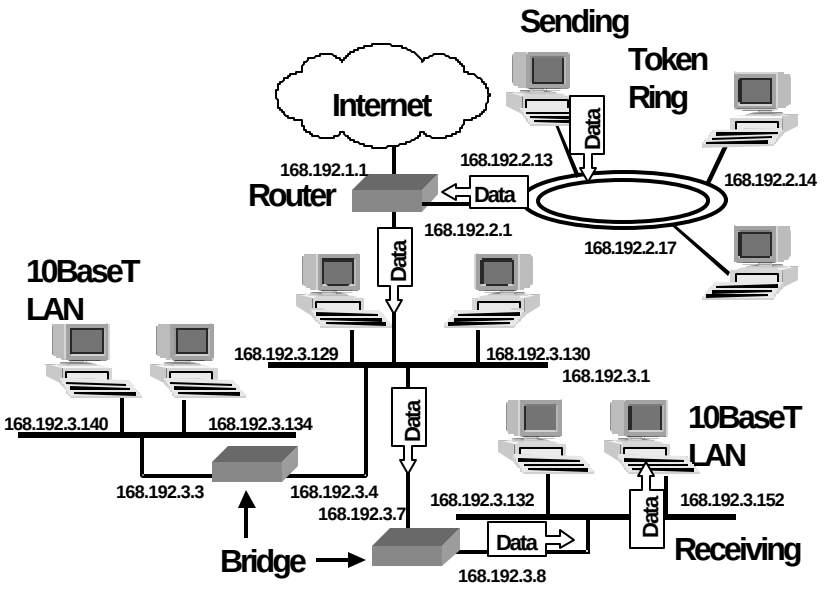
- Switches allow each workstation to transmit information over the network independent of the other workstations.
- These transmissions between computers may be simultaneous. As opposed to hubs, switches are more like the modern telephone system where several private conversations take place at one time.

- Some switches can operate at different speeds, allowing the connection of cables using different bandwidths (example, 10 Mps and 100 Mps).
- There are different types of switches. Layer 3 switches function at the network layer because they can perform translation activities between network segments. Layer 2 switches function at the data link layer because they primarily direct traffic to specific workstations.

Routers

Routers link two or more different networks together, such as an Internet Protocol network. These networks can consist of various types of LAN segments, for example, Ethernet, token ring, or Fiber Distributed Data Interface (FDDI). A router receives packets and selects the optimum path to forward the packet across the network. Routers build a table of all the device addresses (routing table) across the networks. Using this table, the router forwards a transmission from the sending station to the receiving station across the best path.

Routers Direct Traffic from Different Networks via Optimum Paths



- Bridges know the 6-byte hardware address of all workstations on the network segment. In contrast, routers maintain a table of all learned network addresses, for example, 168.192.1.0, 168.192.2.0, and 168.192.3.0 are three IP network addresses.

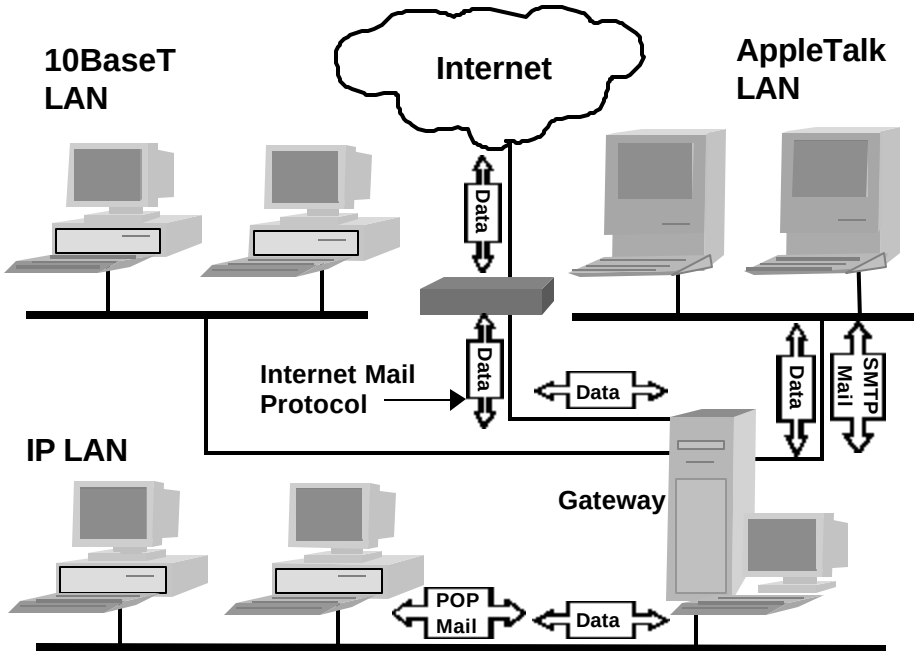
- Routers can increase network efficiency by filtering out broadcast traffic between networks, thus reducing unnecessary traffic between networks.
- Routers can connect different network types such as Ethernet, token ring, and FDDI.
- Routers operate at the network level of the OSI model.

Gateways

Gateways are multi-purpose connection devices. They are able to convert the format of data in one computing environment to a format that is usable in another computer environment (for example, AppleTalk and DECnet).

The term gateway is sometimes used when referring to a router. For the purpose of this lesson, gateways are devices that link different network types and protocols. For example, gateways translate different electronic mail protocols and convey email across the Internet.

Gateways Translate Different Network Protocols



Gateways can operate at all layers of the OSI model since they:

- Can provide a physical link between networks.
- Create junctions between dissimilar networks.
- Translate different network protocols and/or applications (for example, electronic mail between the Internet and a commercial online service with its own mail protocol).

Check Your Understanding

- ♦ Diagram the difference between a switch and a hub and explain the function of each.

Try It Out

Connectivity and Internetworking Devices

Take some time to examine each of the internetworking devices. Notice the similarities and differences among the components.

Materials Needed

- Computer and Pre-Installed Network Interface Card
- Drivers necessary for NIC, if needed
- BayStack 152 and/or 153 Hubs and manufacturer's manuals
- BayStack 350T Switch and manufacturer's manual
- BayStack ARN Router and manufacturer's manual
- Static GuardWrist strap
- Screwdriver

Directions: Examining Networking Equipment

Examine and sketch each piece of equipment carefully. Include the fine details in the illustrations, such as the correct number of ports, pins in the ports, and so on. Title each illustration and include it in your portfolio. You will be using them again in the next lesson. Your sketches must show both a front view and a back view. Use the computer or traditional means to produce your media drawings.

Notice that each piece of equipment tells you what it is, for example BayStack 152 10BASE-T hub. As you can see, the devices' faces look quite similar, so that sometimes the only way you can tell its function is to read the identification name or number.

Notice that there are different types of ports for inserting the various cables. In the next lesson, we will discuss the different cable and connector types. Not all cables and connectors can be used with every piece of equipment. It is important when purchasing networking equipment that you pay attention to the ports. Be sure your drawing shows all of the different ports.

Take time to look through the documentation that comes with the equipment so that you are familiar with its contents. The documentation may help you with your drawing.

Procedures: Removing and Re-installing a Network Interface Card

Before a workstation is attached to a piece of network equipment, a network interface card (NIC) must be installed in the workstation. This is a simple installation, but it requires attention to detail and safety precautions. In order to get you familiar with how

to install a NIC, in this lab you will first remove the pre-installed NIC from your computer before re-installing it.

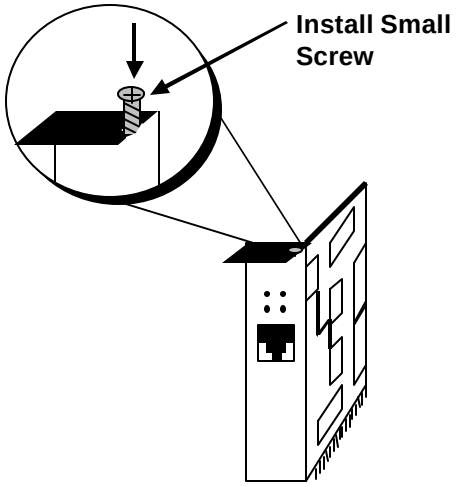
Before Installation

Computers are made from microchips, which are built from transistors. Transistors require only a small amount of electrical current to run powerful computers. Voltage associated with static electricity can be as high as 25,000 volts, enough to damage a computer's electronic circuitry; therefore, static guard wrist straps for grounding purposes are essential for preventing unwanted static electricity discharges from destroying computer components. Also, review personal safety rules for prevention of electrical shock.

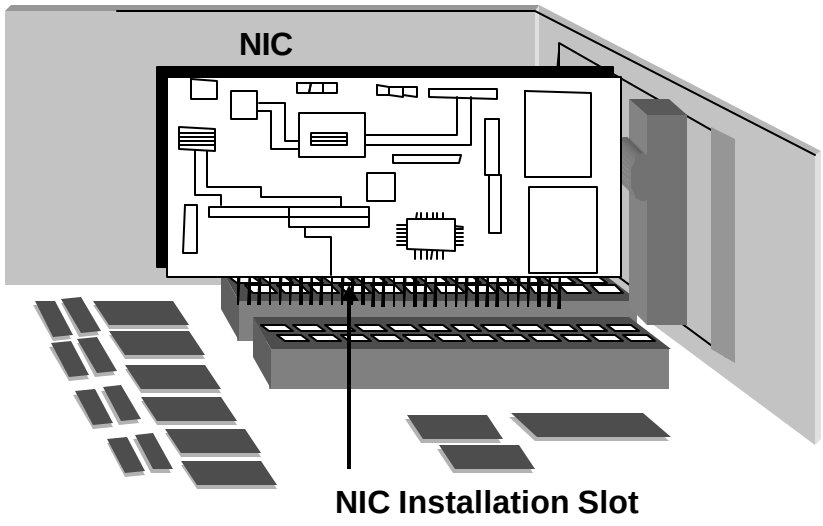
As you complete this activity, keep a record of your activities and observations for inclusion in your Logbook. Once again, record problems encountered, positive outcomes, and so on.

You will remove and re-install a NIC. It is vital that you keep detailed, labeled drawings/sketches of the steps you take, cable placements, and so on, when you remove the NIC. In that way, you can be sure of replacing everything properly, without affecting the operation of your workstation.

1. Wear a wrist strap that connects you to the computer. See your instructor if you are unsure of how to use the wrist strap. The resistance end needs to be wrapped firmly to the wrist. The metal end needs to be attached to the housing of the power supply. This process provides a source to ground, reducing the chance of static electricity damaging the workstation.
2. Keep notes and detailed sketches as you complete this installation and record in your Logbook any problems or frustrations that occur.
3. Turn off the computer.
4. Disconnect the power cord to the computer workstation.
5. Disconnect any external cables attached to the workstation.
6. Sketch the workstation and ports. Label cable and connections as a reference for re-installation.
7. Locate the screws that secure the chassis and remove them. Gently remove the cover from the workstation.



8. Locate the NIC installed in the workstation. If necessary, remove the screw(s) securing the NIC to the chassis. Gently remove the card from its slot.
   - **NEVER TOUCH THE ELECTRICAL CONTACT POINTS WHEN HANDLING COMPUTER COMPONENTS. THE MOISTURE FROM YOUR BODY CAN CAUSE DAMAGE TO THE CIRCUIT BOARDS.**
9. Set the NIC gently down on a clean table or static pad to examine.
10. Sketch the NIC from various vantagepoints. The end view should include all the ports. Note the brand name and number of the NIC if it is available.
11. When you have finished sketching the NIC, using care not to touch any of the circuitry, align the NIC with the slot.
12. Gently, but firmly, press the card into the slot. Do not rock the card.



13. If the card is fully seated in the slot, the bottom edge of the card will be hidden.

14. Fasten the flanges into the exterior opening with screws to secure the NIC in place.
15. Place the case over the workstation and replace all screws and cables. Test the connectivity of the NIC by attempting to connect the network.
16. Restart your computer.
17. From the desktop window, double click

.
18. Double-click

.
19. Computers in your workgroup will appear as icons

Rubric: Suggested Evaluation Criteria and Weightings

Criteria	%	Your Score
Participation and teamwork	25	
Detailed diagram of hubs, switches, and routers with attention paid to accuracy of ports	25	
Successful removal and re-installation of NIC	25	
Detailed notes and comments on re-installation integrated into Logbook for future reference	25	
TOTAL	**100**	

Stretch Yourself

WINIPCFG: Windows 95/98 Network Utility

In order for data signals to be transmitted and received, computer nodes must have unique addresses, much like your home address is needed to receive mail from the post office. Your home address is unique. Its uniqueness is what allows your mail to be delivered to your unique address and not to another location. Computer workstations on networks need unique addresses also so data is transmitted between the source and destination devices accurately.
Although there is much more to learn about networks, their components, and protocols, it is possible to view the addresses of workstations.

Materials Needed

- Networked computer with Windows 95 or 98

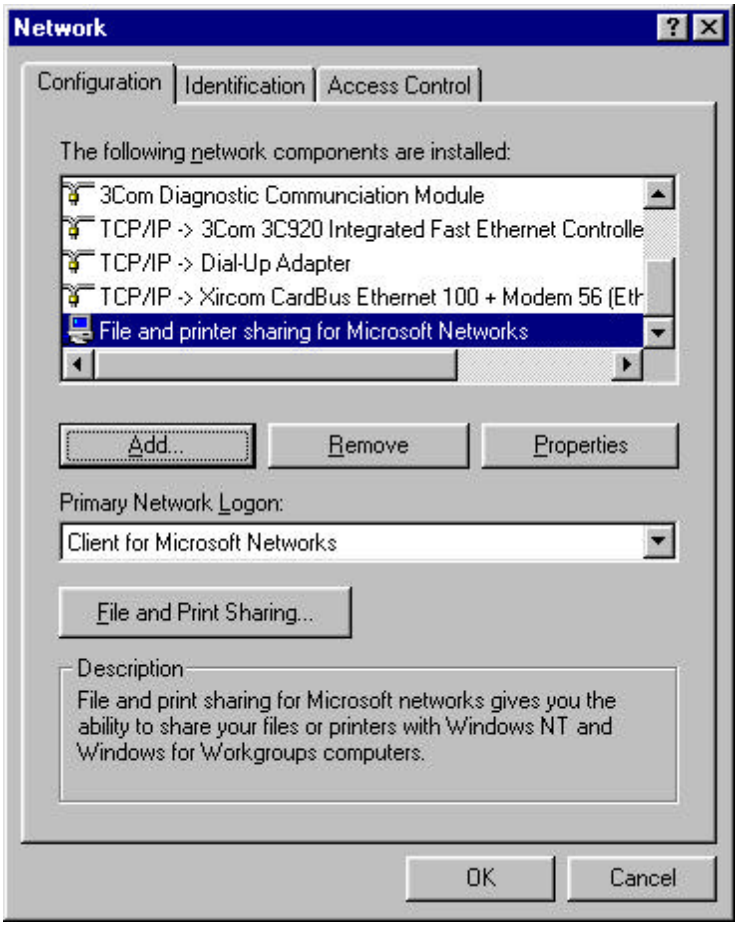
Directions: Configuring TCP/IP Protocols

TCP/IP is one of the most important sets of protocolsin networking today.It is the backbone of the Internet and is everywhere from the smallest to the largest network. You will learn more about TCP/IP later in this course. It comes with Windows95/98. In this activity, you will set up the TCP/IP protocols for your workstation.

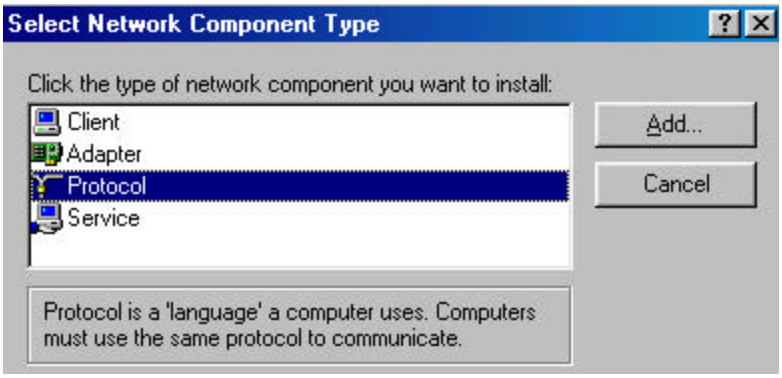
Procedures: Configuring TCP/IP Protocols

1. Start your computer.
2. Click

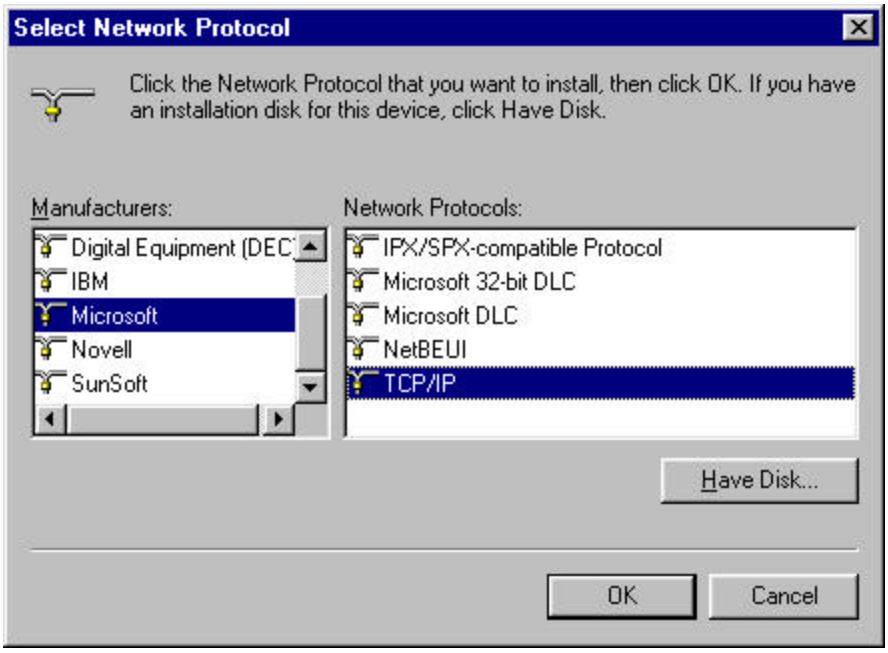
.
   - Select Settings.
   - Select Control Panel.
3. In the Control Panel window, double-click the Network icon.
4. In the Network window, highlight File and print sharing for Microsoft Networks.


Network
Configuration
Identification
Access Control
The following network components are installed:
3Com Diagnostic Communciation Module
TCP/IP -> 3Com 3C920 Integrated Fast Ethernet Controlle
TCP/IP -> Dial-Up Adapter
TCP/IP -> Xircom CardBus Ethernet 100 + Modem 56 (Eth
File and printer sharing for Microsoft Networks
Add...
Remove
Properties
Primary Network Logon:
Client for Microsoft Networks
File and Print Sharing...
Description
File and print sharing for Microsoft networks gives you the ability to share your files or printers with Windows NT and Windows for Workgroups computers.
OK
Cancel

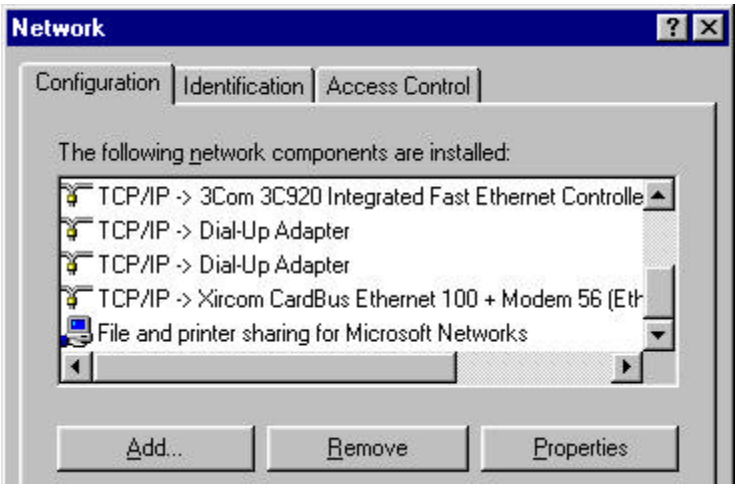
5. Click .
6. In the Select Network Component Type window, highlight Protocol.



7. Click .
8. In the Select Network Protocol window, highlight Microsoft and TCP/IP.



9. Click OK.
10. You will see the Network Configuration window next. Notice that the TCP/IP protocol has been added.

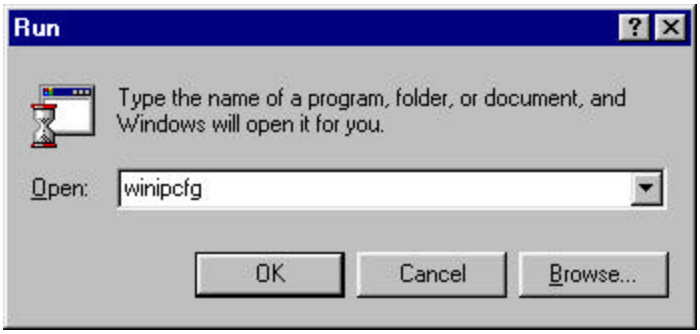


Directions: WINIPCFG

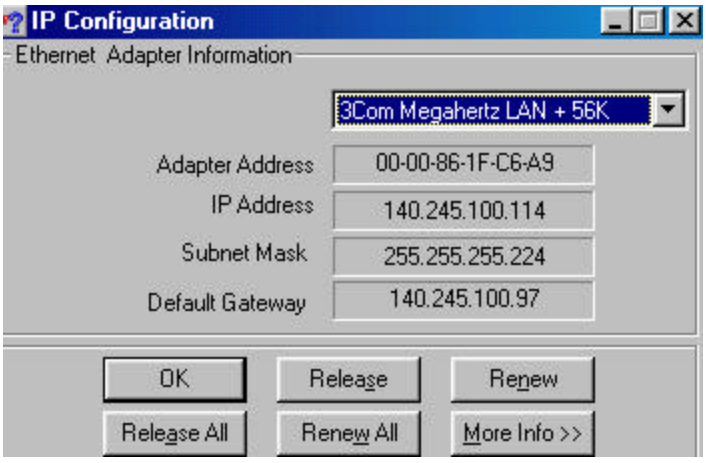
WINIPCFG is a network utility packaged with the Windows 95/98 operating system. In this portion of the lab, you will run WINIPCFG and discover the Internet Protocol (IP) addresses of your workstation and the other internetworking devices on the network.

Procedures: WINIPCFG

1. At a workstation connected to a Network, click the Start menu of your PC.
2. Highlight Run. In the dialog box that appears, type **winipcfg**.

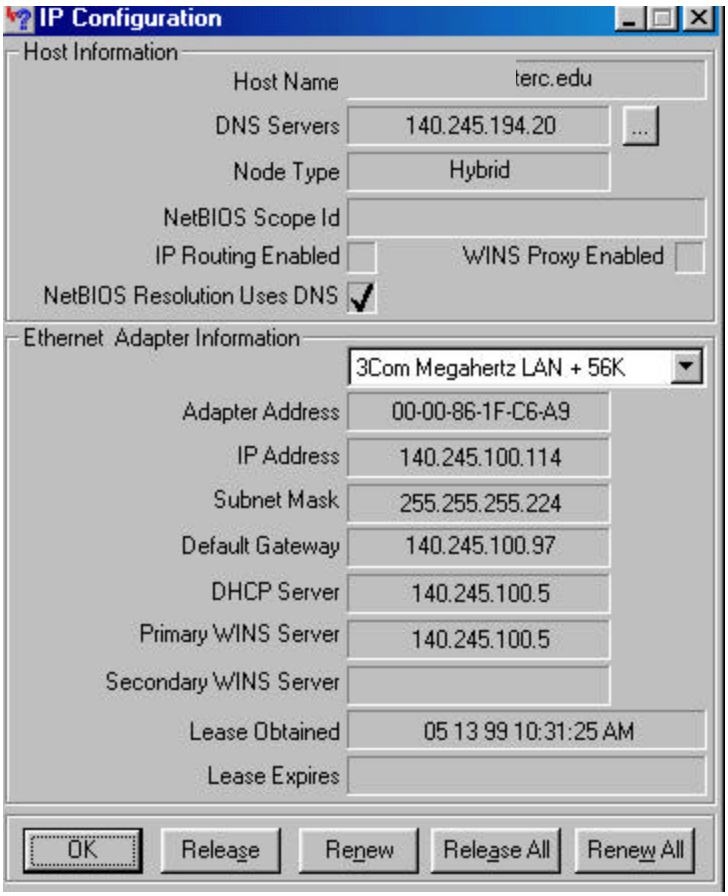


3. Click OK.
4. The IP Configuration box will appear. Depending on how the network is set up and how many network interface cards are installed in the workstation, there may be more than one configuration.



5. If the IP Address is all 0s, you may have to choose a NIC (often called an Ethernet adapter) from the pull-down menu. Once you have chosen the NIC, you will see the addresses of the adapter, the workstation's IP, the subnet mask, and the gateway. The subnet is a network that is a component of a larger network.
6. Copy the following information from *your* workstation's IP Configuration. Note that this address is unique for your workstation.
    - Adapter Address _____
    - IP Address _____
    - Subnet Mask _____
    - Default Gateway _____

7. Click More Info >>. Much of what will be displayed will not make sense right now. However, it is possible to see each workstation, and using the hardware (adapter) and IP, track network device addresses. Bridges, routers, and gateways are able to learn these addresses and direct traffic to the correct workstation.



8. Create a diagram of the network devices and workstations connected to your network.
9. Gather the Adapter and IP addresses of the other network workstations from your fellow students and label each workstation on the diagram with the correct addresses. Save the diagram in your Portfolio for future use.
10. In a short paragraph in your Logbook, note any discoveries made from the diagram and the addresses corresponding to the network devices and workstations.

Rubric: Suggested Evaluation Criteria and Weightings

Criteria	%	Your Score
Participation and teamwork	25	
Detailed network diagram with correct IP and Adapter Addresses	50	
Analysis and synthesis of information	25	
TOTAL	**100**	

Network Wizards

IP Addressing Research

Materials Needed

- Internet connection

Directions

1. During this lesson and the Stretch Yourself lab, the concept of addressing was introduced. There is significance to the numbers and their sequence in an address.
2. How are the numbers in the addresses related to the information learned from the data transmission lesson?
3. Using the Internet, research IP addressing.
4. Write a one-page paper on IP addressing and the significance of the numbers and sequence to put in your Portfolio. Include your references at the end of the paper.

Rubric: Suggested Evaluation Criteria and Weight

Criteria	%	Your Score
On-time delivery of assignment	10	
Content and quality of one-page research paper	50	
Organization, spelling, grammar	25	
References	15	
TOTAL	**100**	

Summary

In this lesson, you learned the following:

- The identification of network connectivity and internetworking devices.
- To match the appropriate level within the OSI model to which each device is assigned.
- The comparison of the functionality between connectivity and internetworking devices.

Review Questions Name_____

Lesson 1-2: Connectivity and Internetworking Devices

Part A

Identify each item as either a connectivity device or an internetworking device by placing a "C" or an "I" next to the item.

	1. Bridge		7. Switch
	2. Multistation Access Unit		8. Gateway
	3. Transceiver		9. Router
	4. Network Interface Card		10. Repeater
	5. Hub		11. Media Filter
	6. Media Dependent Adapter		

Part B

Identify which layer of the OSI model each device is assigned.

	1. Bridge
	2. Repeater
	3. Network Interface Card
	4. Router
	5. Transceiver
	6. Multistation Access Unit
	7. Hub
	8. Switch
	9. Media Dependent Adapter
	10. Media Filter
	11. Gateway

Part C

1. Compare the functions of bridges, hubs, repeaters, routers, and switches. Tell which layer of the OSI each device functions.

Scoring

Rubric: Suggested Evaluation Criteria and Weightings

Criteria	%	Your Score
Part A: Identify network connectivity and internetworking devices.	22	
Part B: Identify the appropriate level within the OSI model to which each device is assigned.	22	
Part C: Compare the functionality of connectivity and internetworking devices.	56	
TOTAL	**100**	
Try It Out	**100**	
Stretch Yourself	**100**	
Network Wizards	**100**	
FINAL TOTAL	**400**	

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